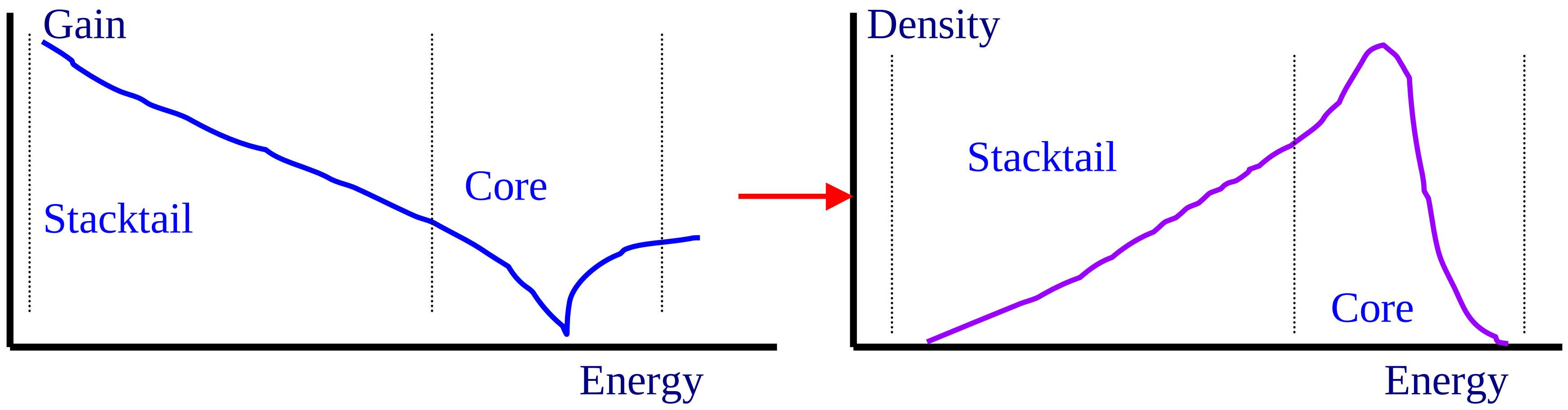
Stochastic Stacking for Run IIb

- Design Goals
  - ⇒ flux 80 mA/hour
  - ⇒ Recycler cooling requires $\leq$ 10 eV-sec, 15 π every 15 minutes
- Assumptions:
  - ⇒ Recycler final repository for anti-protons
    - » Stochastic cooling performance degrades with increasing density
    - » Electron cooling performance improves with increasing density
  - ⇒ Optimize for maximum flux
    - » Not maximum momentum density!
  - ⇒ Frequent transfers from Accumulator to Recycler (<30 minutes between transfers)
- Last Presentation (17 Sept 01): ~50 mA/hour design
- AAC Meeting (12 Dec 01): ~70 mA/hour design

Stochastic Stacking

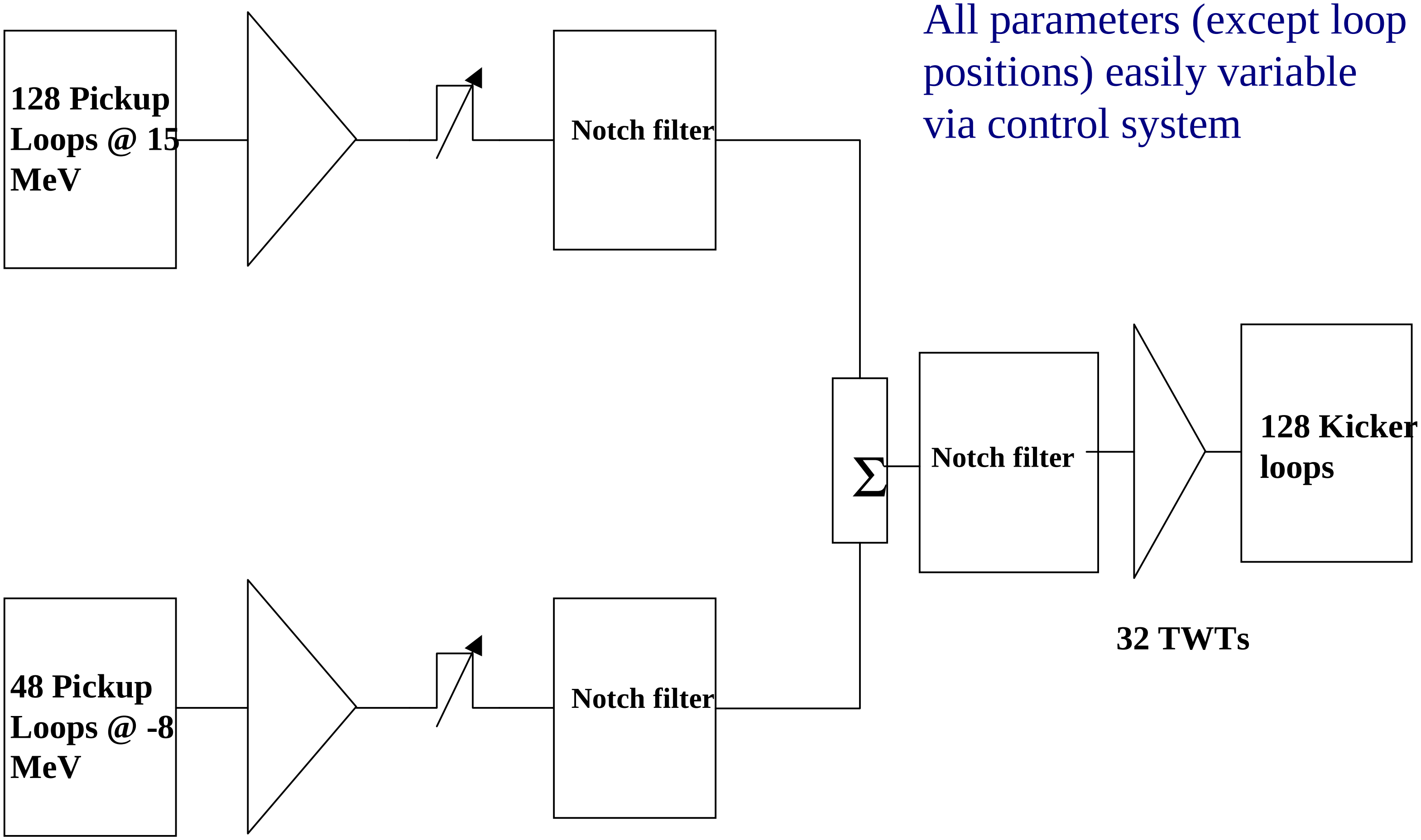
- Simon van Der Meer solution:
  - ⇒ Constant Flux: $\frac{\partial \psi}{\partial t} = \text{constant}$
  - ⇒ Solution: $\frac{\partial \psi}{\partial E} = \frac{\psi}{E_d}$, where E_d characteristic of design $\psi = \psi_0 \exp\left[\frac{(E - E_i)}{E_d}\right]$
  - ⇒ Exponential Density Distribution generated by Exponential Gain Distribution
  - ⇒ Max Flux = $(W^2|\eta|E_d)/(f_0 p \ln(2))$



Using log scales on vertical axis

Schematic diagram of stacktail electronics

All parameters (except loop positions) easily variable via control system



Design Specs

- Design 1: vary transverse aperture
  - ⇒ Gain ~ $e^{-(\pi\partial x/d)}$ where d is transverse aperture
  - ⇒ E_d ~ d for our model
  - ⇒ 1.6x wider, needed lots of power to account for loss of sensitivity
  - ⇒ ~50 mA/hour
- Design 2: vary pickup position
  - ⇒ Keep same transverse aperture, vary sum to vary E_d
  - ⇒ Move pickup locations a few mm, change relative gains and phases
  - ⇒ ~75 mA/hour for 30 minutes
  - ⇒ ~70 mA/hour with transfers every 15 minutes

Both designs limited by how well move beam off deposition orbit!

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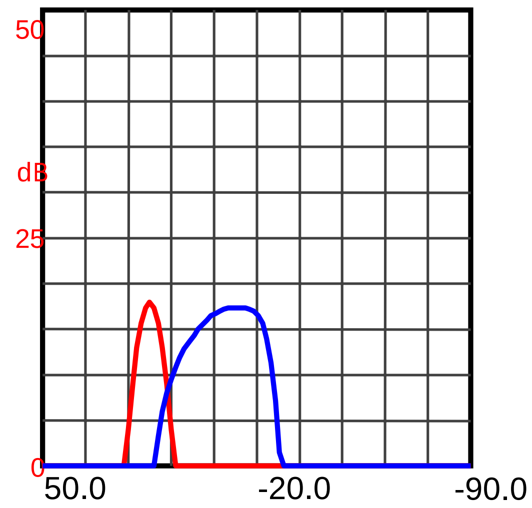
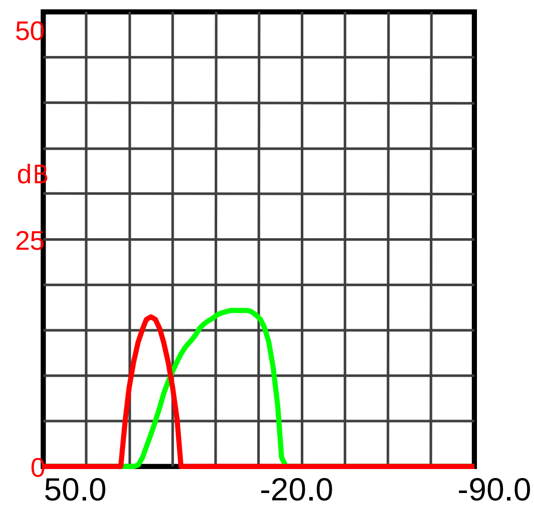
Input Longitudinal Phase Space

- Moving beam off deposition orbit depends on:
  - ⇒ Gain: more efficient at higher gain
  - ⇒ Cycle time: more efficient with longer cycle time
  - ⇒ Beam width: more efficient with smaller width (assuming completely full buckets)
- Constraints:
  - ⇒ Gain: power and matching
  - ⇒ Cycle time: longer cycle, less total flux
  - ⇒ Beam width: Debuncher cooling performance



6 MeV width



8 MeV width

Gain Constraints

- Match stacktail gain to core gain to preserve gain slope

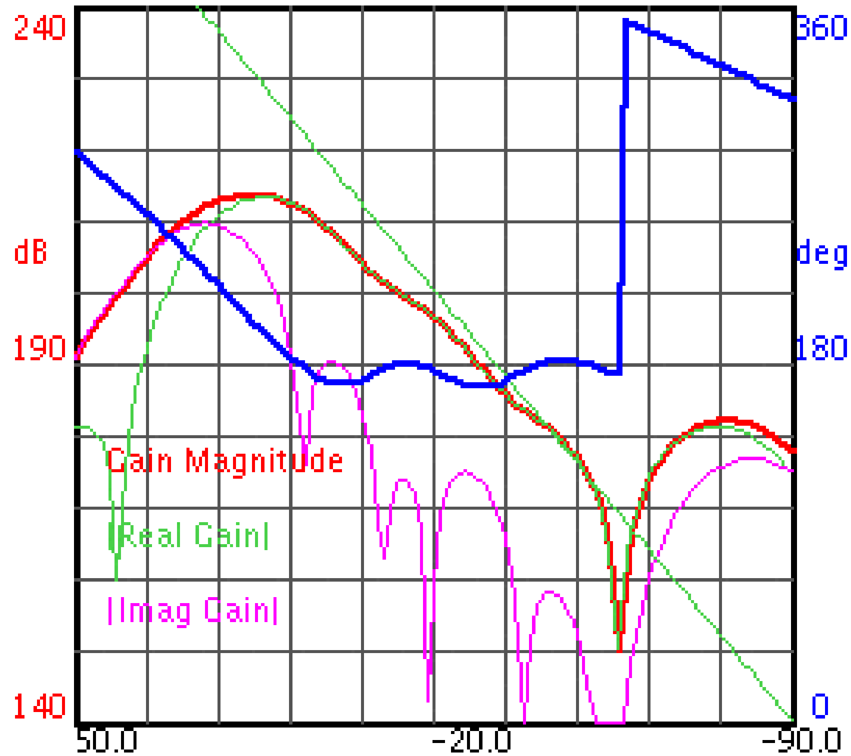
Ψ is local beam density

F is local kicker voltage

- $\Rightarrow$ Cooling term α $F\Psi$
- $\Rightarrow$ Diffusive beam heating α $F^2\Psi$

- $\Rightarrow$ As density increases (core), necessary to decrease kicker voltage (system gain) so that cooling term > diffusive heating term

- $\Rightarrow$ Maximum gain for given stack size



Simulation Performance
6 MeV bucket

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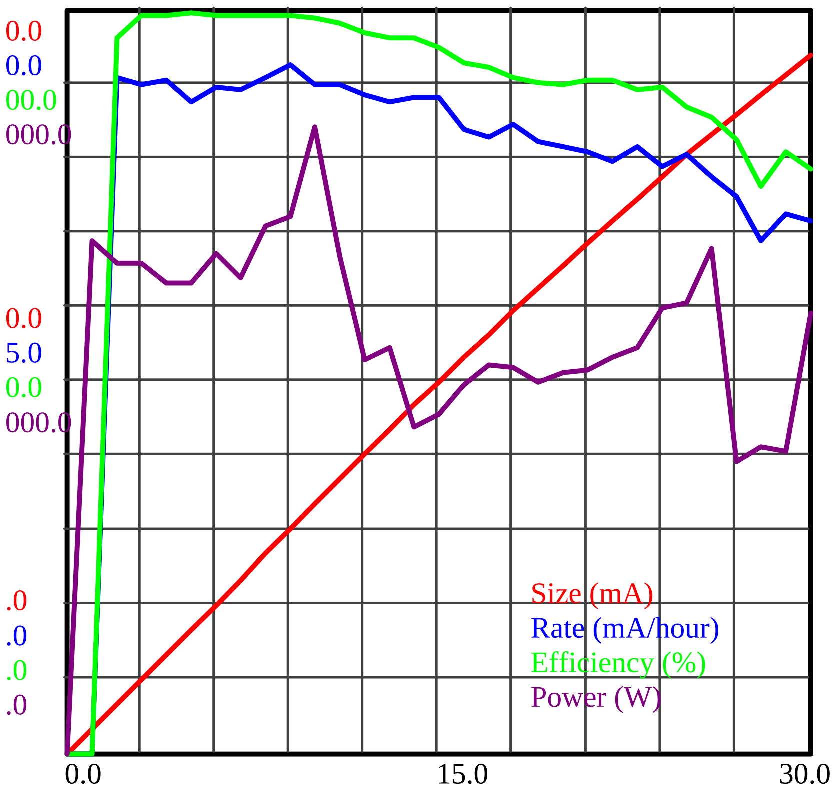
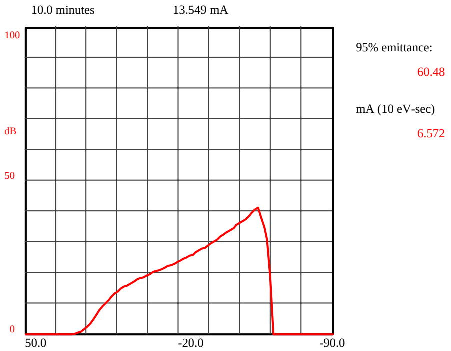
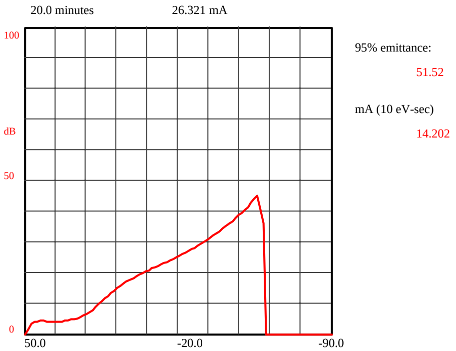
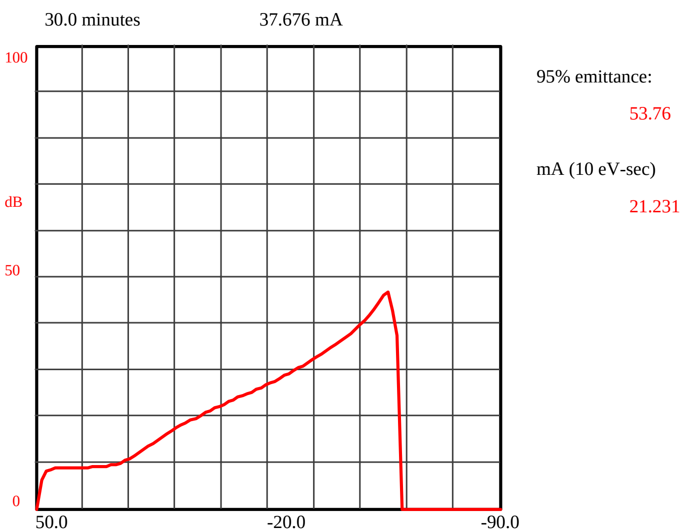








Mean Rate:	75.7 mA/hour
Efficiency:	92.7%
Mean Power:	1150 W

Single Pulse Evolution Analysis

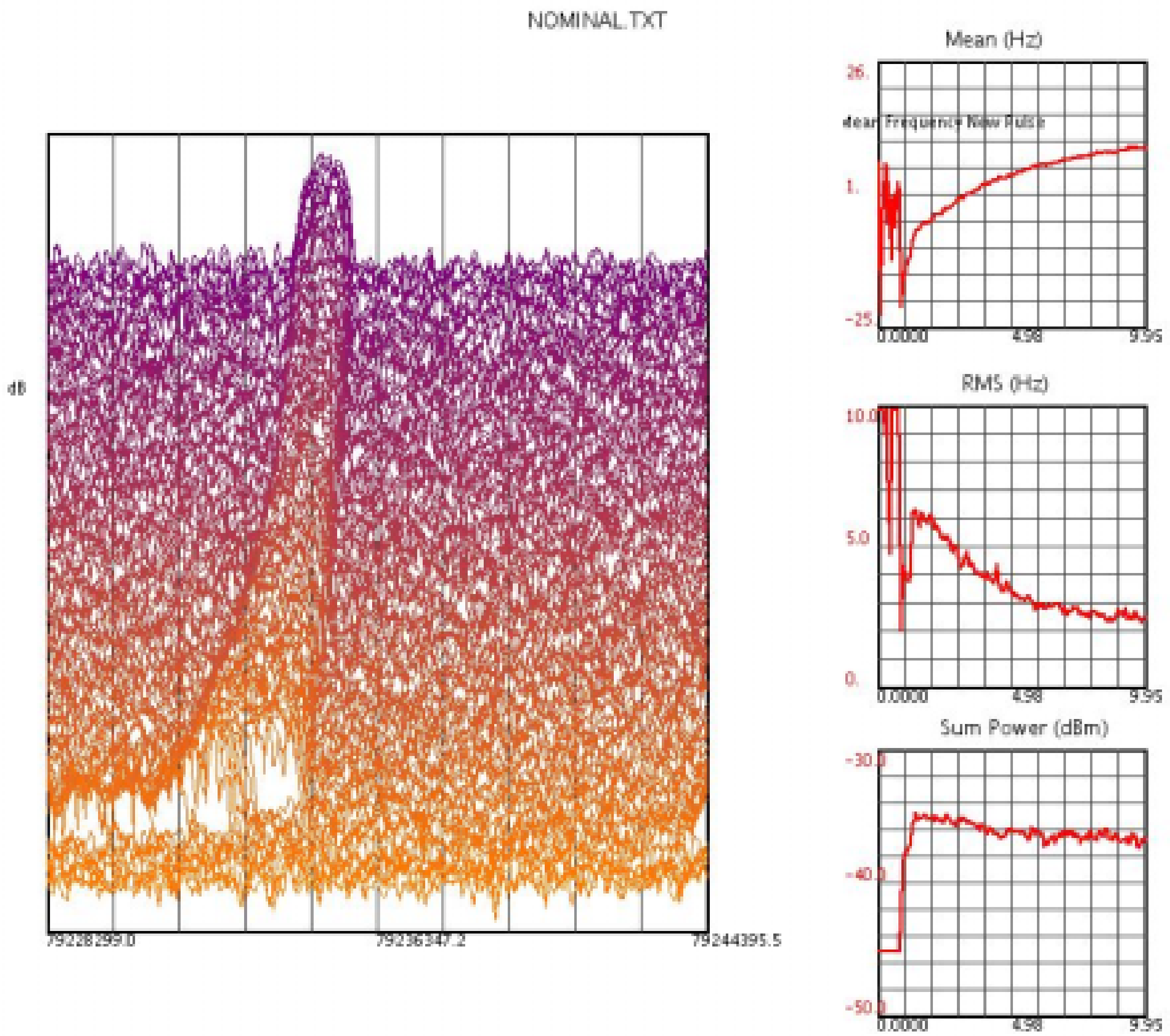
- Study how beam moves off the deposition orbit:
  - ⇒ Single pulses into the Accumulator
  - ⇒ Use 79 MHz longitudinal Schottky & VSA
  - ⇒ Start when beam is dropped off, follow for ~9 seconds

  - ⇒ Traces at 5 Hz, 3x average

  - ⇒ For 5 gain settings:
    - » Nominal Stacktail settings
    - » ±3 dB
    - » ±6 dB

Nominal Settings

- Calculate noise floor, then mean, RMS, & power in pulse
- Mean with respect to Accumulator Central Frequency (628840 Hz)
- RMS at the fundamental
- Actually got 2 pulses on this one



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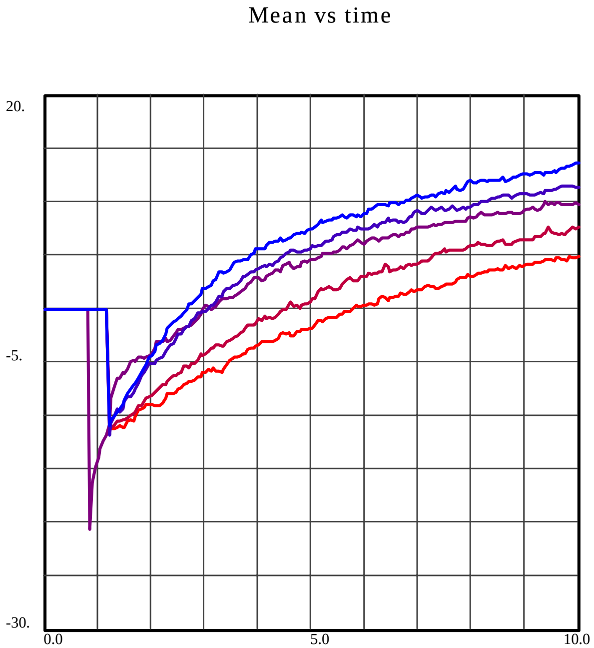
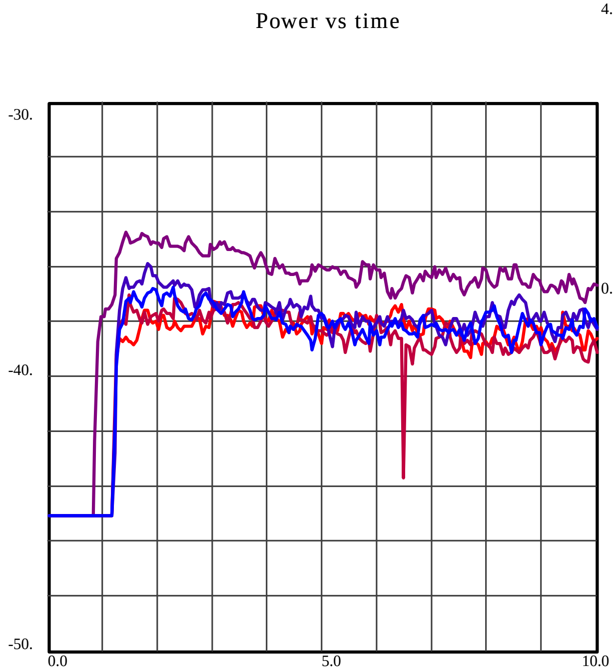
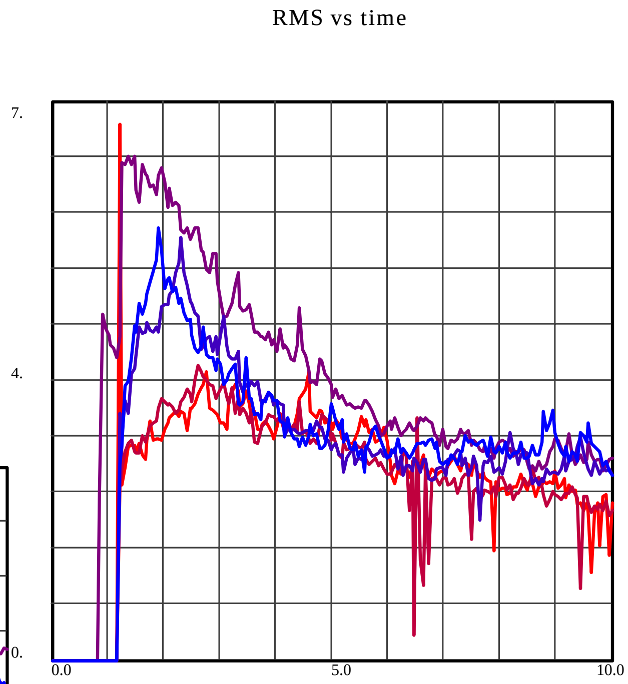
18-Mar-02
10

5 data sets



-6 dB
-3 dB
Nominal
+3 dB
+6 dB





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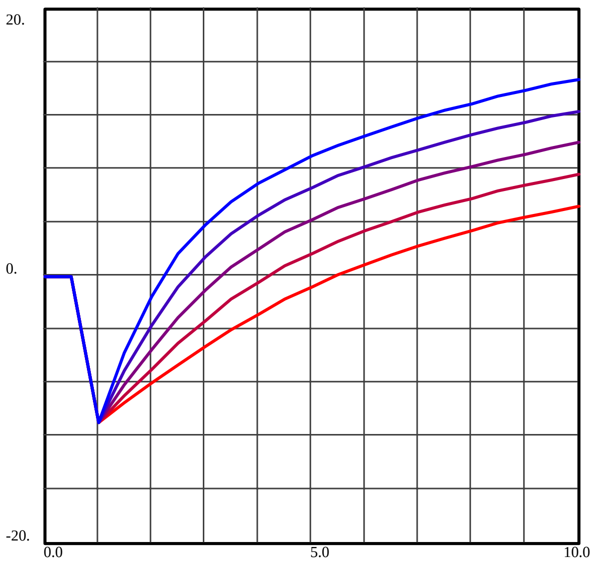
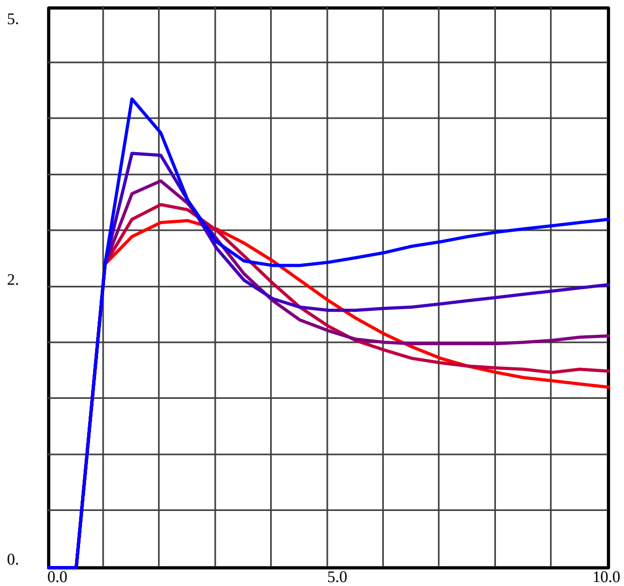
Simulation data sets

Mean vs time

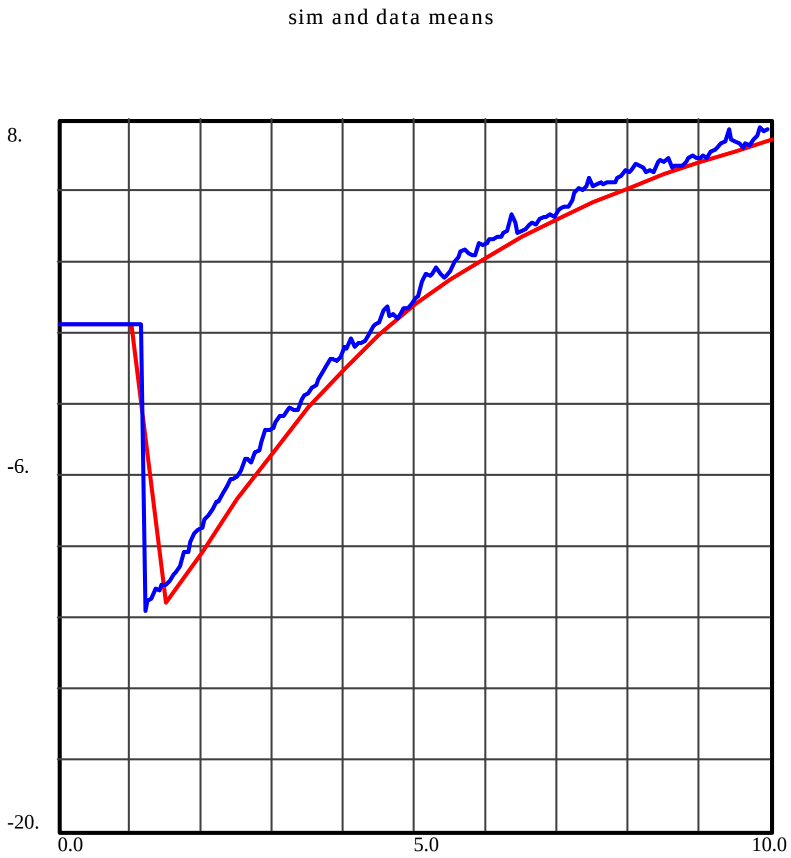


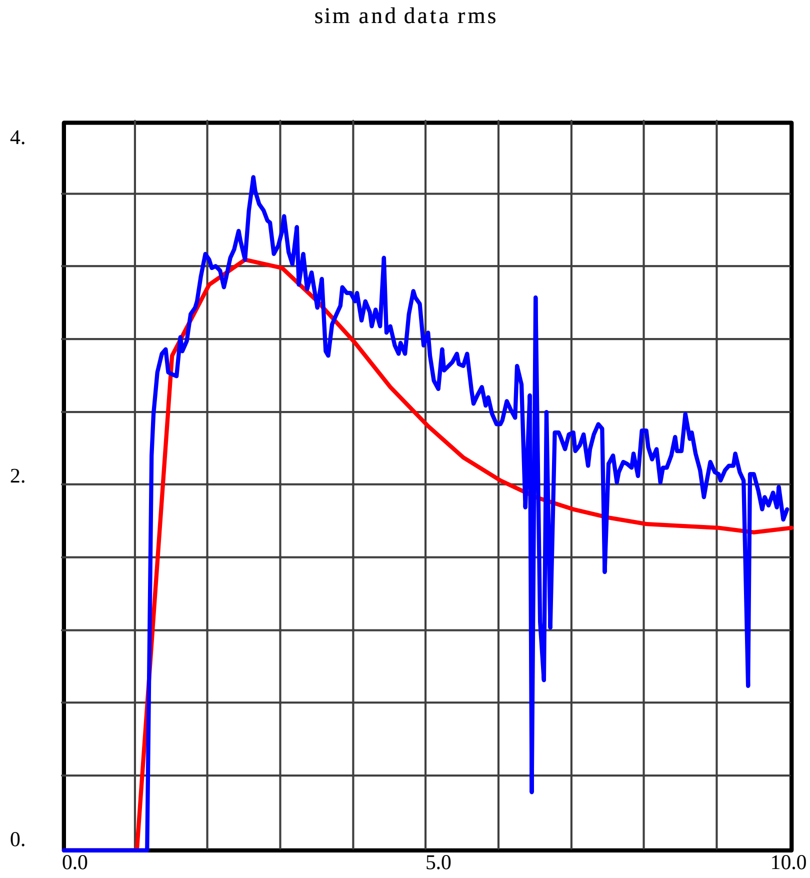
-6 dB
-3 dB
Nominal
+3 dB
+6 dB

RMS vs time



Data and Simulation





RMS Behavior

Expect profile to become exponential in form

⇒RMS grows initially asymmetric

⇒As density increases, asymmetry decreases

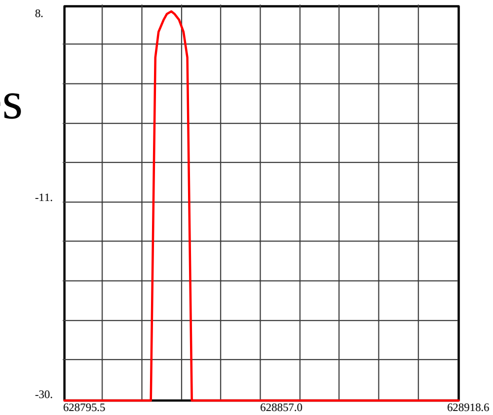
⇒Simulation at times

»T=1 second

»T=2 seconds

»T=9.5 seconds

Trace #2



Mean: -10.94

RMS: 2.72

Power: 15.72

Trace #4

Mean: -5.39

RMS: 3.46

Power: 15.72

Trace #19

Mean: 9.66

RMS: 2.06

Power: 15.72

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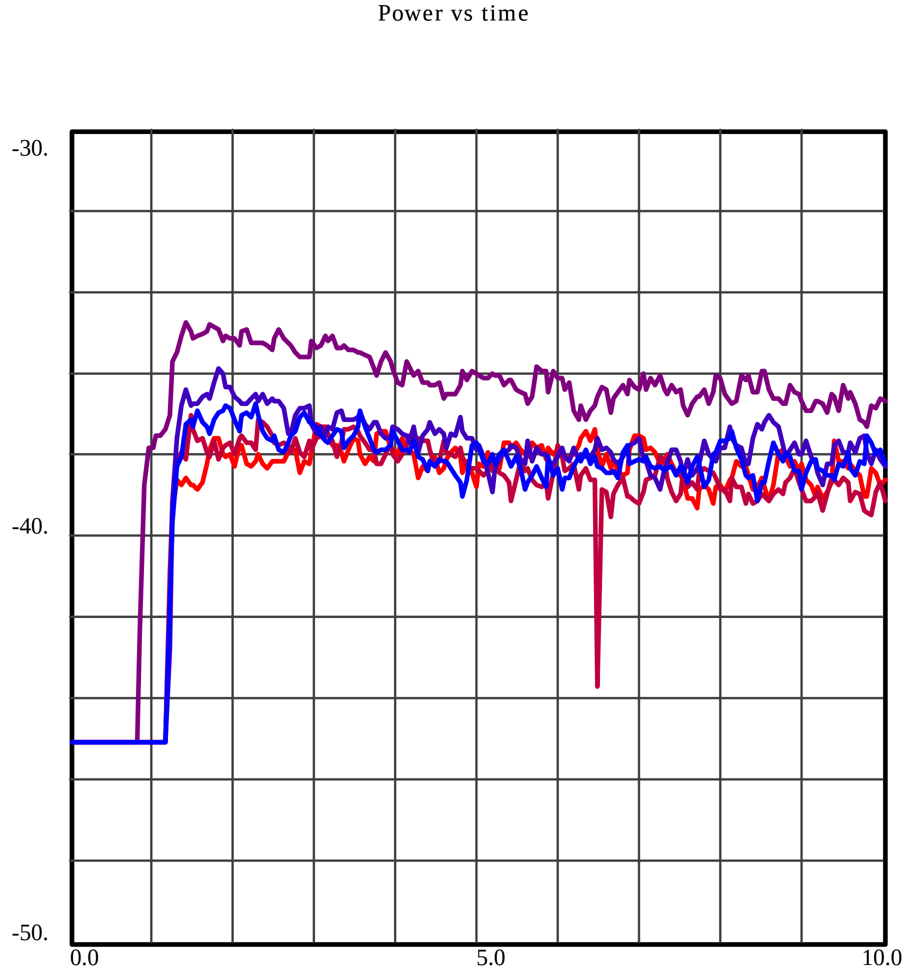
Losing beam?

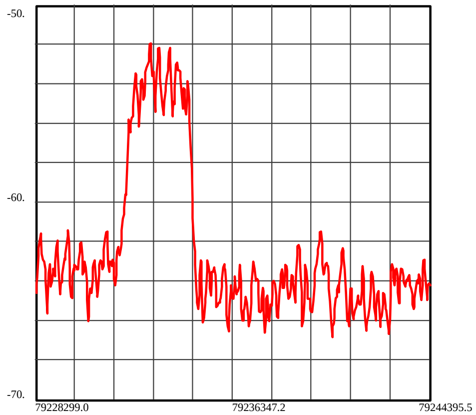


-6 dB
-3 dB
Nominal
+3 dB
+6 dB

Lose about 2 dB
From start to end?

Losing Beam?

Trace #40

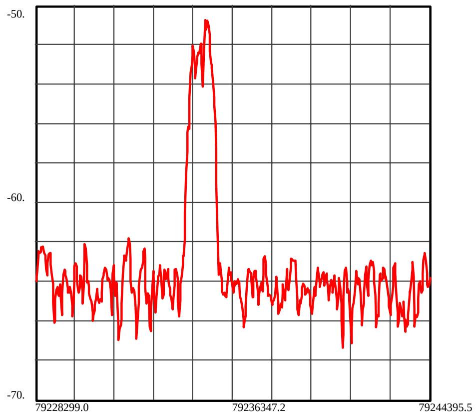


Mean: -4.07

RMS: 6.01

Power: -35.06

Trace #194



Mean: 9.99

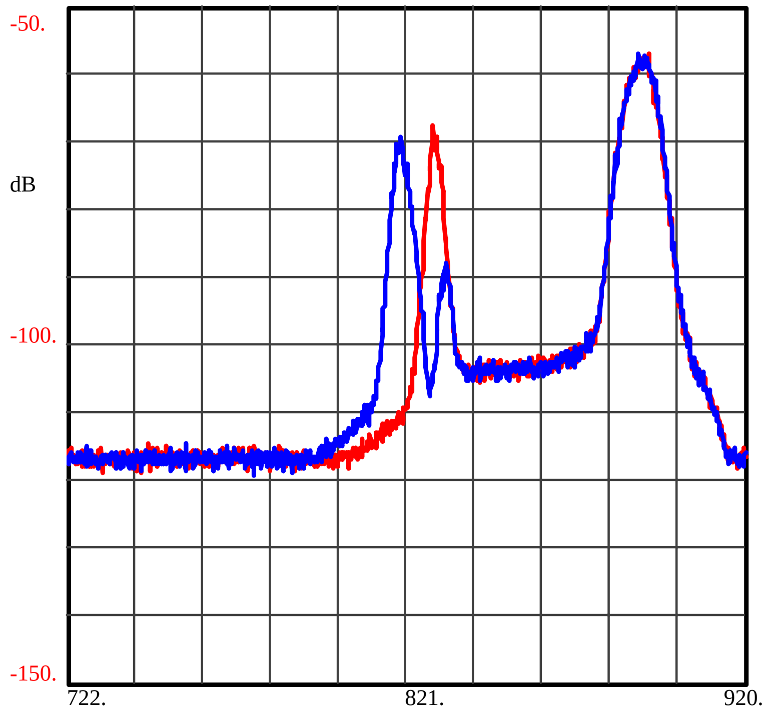
RMS: 2.54

Power: -37.11

- ~20% lower integrated power after 9 seconds
- In 4 of the 5 traces (-6 dB trace is ~constant)

RF Phase Displacement

- Put 0.5 mA at 628830 (nominal deposition orbit)
- Triggered 1 ARF1 stacking cycle

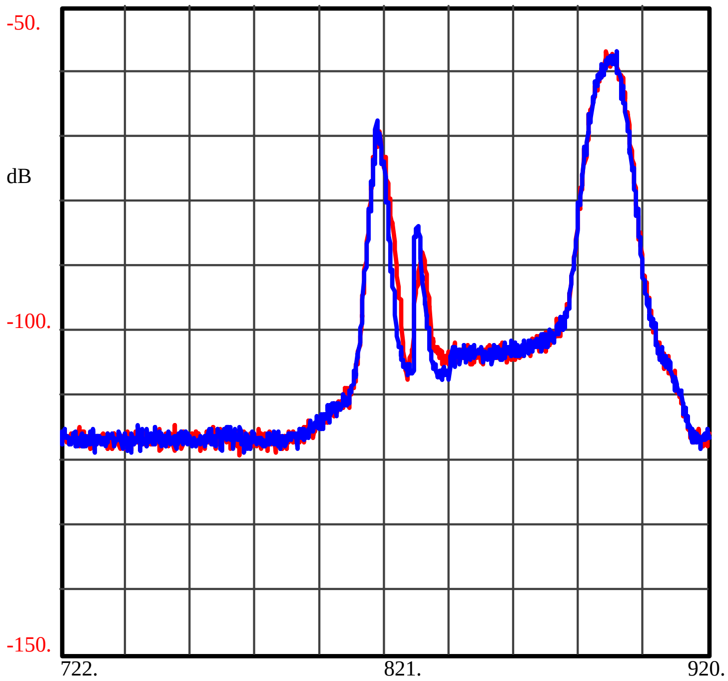


Initial and Final distribution in data

Time:	not known
Resolution Bandwidth:	not known
Video Bandwidth:	not known
Sweep Time:	not known

Data and Simple Model

- Simple model:
  - ⇒ F<628830, displace by bucket height
  - ⇒ F>628830, displace fraction by bucket height (from 1 to 0 at edge of bucket)



Data and Model distribution

Time:	not known
Resolution Bandwidth:	not known
Video Bandwidth:	not known
Sweep Time:	not known

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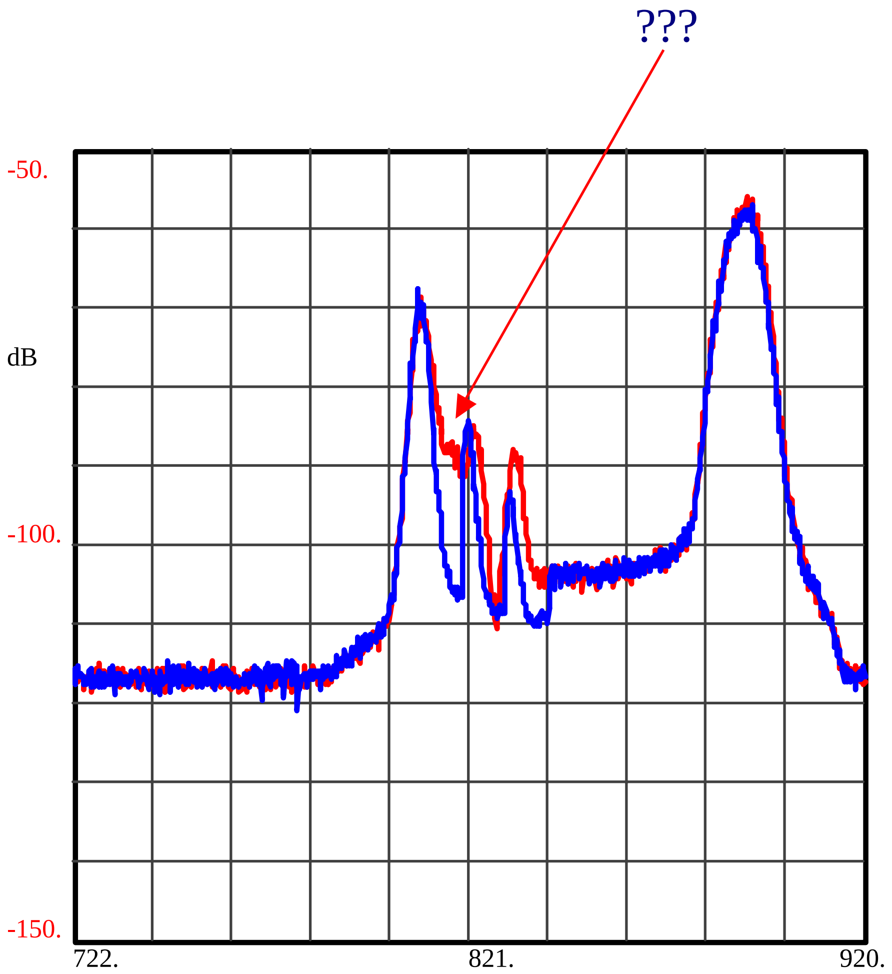
Two ARF1 cycles!



Data and Model distribution

Time:	not known
Resolution Bandwidth:	not known
Video Bandwidth:	not known
Sweep Time:	not known

What I am working on

- Pulse evolution & RF Phase displacement measurements: list of things to measure when opportunity arises

- New system designs to gain margin:
  - ⇒ Increase bandwidth (4-8 GHz)
    - » New pickup design: estimate ~1 year development time or more?
  - ⇒ increase bandwidth (2-4 GHz + 4-6 GHz)
    - » Use current 2-4 GHz and 4-8 GHz (which are really more like 4-6 GHz)